did the lime alone without the copper, as a trial demonstrated. There seems to be some mutual reaction between the Bordeaux and the lichen substance, probably the fungous part, since a test with unicellular algæ gave no such results. This point is worthy of further investigation, and is of interest on account of the possibility of its throwing light on the general question of the action on fungi of the copper compound in Bordeaux mixture and in other insoluble copper preparations. Microscopical examination of a small portion of a lichen thallus which had been treated with Bordeaux mixture and had turned yellowish and dried, showed no marked changes. The chlorophyll, however, had turned a brighter yellow color, and to this is probably due the general change of color.

SUMMARY.

(1) Bordeaux mixture is an effective remedy for lichens on pear trees.

(2) Eau celeste, chloride of lime, (1 per cent solution) and bichloride of mercury, (one-tenth of 1 per cent solution) proved unsatisfactory.

(3) There seems to be a reaction between the lichens and the Bordeaux mixture in which the flocculent precipitate constituting the active principle of the latter is probably partially dissolved and absorbed. As a result the lichens assume a yellow color and die.

DESCRIPTION OF PLATES.

Plate XXX. A Bartlett pear tree near Scotland, Va., infested with lichens. From a photograph taken October 19, 1892.

XXXI. Bartlett pear tree in the same orchard which had been treated with Bordeaux mixture, showing the dead and shriveled remains of the lichens. From a photograph taken October 19, 1892.

NOTES ON FOSSIL FUNGI.

By JOSEPH F. JAMES.

The enormous number of species and individuals of living fungi presupposes their existence in the past. But their evanescent nature and their peculiar structure render their occurrence in a fossil state comparatively rare. There is great difficulty in keeping many of them with all the care and experience of botanists, and it is natural to expect the vicissitudes of time will operate against rather than in favor of their preservation. During those periods of geological time when vegetation was mainly confined to the sea, we can scarcely expect to find fungi, so that not until the Devonian epoch need we look for evidences of their presence. The Carboniferous period, however, with its

wonderful richness of vegetation, might be expected to produce a greater or less number of species. As a matter of fact, however, they have so far been very rarely found in this formation, and it seems doubtful whether some of those that have been described as fungi are really such. Perhaps the preponderance of ferns, lycopods, and similar forms may partly explain the absence of parasitic fungi, for we know that these plants in our days are rarely attacked by them. The peculiar conditions of deposition of the coal also militate against the preservation of saprophytic forms. Experiments made by Lindley about 1835 to ascertain the probability of plants being preserved in water show that of 3 species of woody fungi only shapeless masses remained at the end of two years.* In Cretaceous and Tertiary times, when the higher types of dicotyledons predominated, parasitic species are more likely to occur, and here they are not uncommon. In the following notes upon some of the species described as fungi and occuring in the older geological formations an endeavor has been made to ascertain their actual position.

The earliest described species, supposed to be a fungus, to which reference has been found was named by Lindley and Hutton in 1831, *Polyporites bowmanni*.† The authors considered it doubtful whether it really belonged to the vegetable kingdom, but they compared it with certain fungi having a hymenium, like *Boletus*, *Polyporus*, etc. In 1877 Lesquereux‡ referred to the species and discussed its nature, stating that a specimen somewhat similar had been found in the anthracite Coal Measures near Pottsville, Pa. It did not, however, throw any light upon the true nature of the fossil. It is compared to certain shaly fragments colored in concentric zones by iron, and which occur in the Tertiary lignite of the Rocky Mountains. Finally, in 1889 William Carruthers stated that instead of its being a fungus it had been ascertained to be the scale of a ganoid fish.§ Thus *Polyporites bowmanni* was at last disposed of.

In 1869 Hancock and Atthey published a paper "On some curious fossil fungi from the black shale of the Northumberland coal field."‖ They stated that in the interior of certain lenticular bodies they found numbers of ramifying tubes. They were not calcareous, and were considered to be fungi. A comparison was made with *Sclerotium stipitatum* B. & C., 1862, and the statement made that the description of that species would fit one of the fossil forms very well. Some of the lenticular bodies appear homogeneous, but this is considered merely apparent.¶ Occasional oval, spore-like bodies were found in the threads, and scattered through the substance of the fungus. In

* Fossil Flora of Great Britain, by Lindley and Hutton, Vol. III, 1837, p. 5.

† Loc. cit., Vol. I, 1831–'33, p. 185, pl. 65.

‡ Proc. Am. Phil. Soc., Vol. XVII, 1877, p. 173.

§ Proc. of the Geol. Asso., Vol. XI, London, 1889, p. xxi.

‖ Ann. & Mag. Nat. Hist., 4th ser., Vol. IV, 1869, pp. 221–228, pls. IX, X.

¶ Out of 126 sections made, 16 appeared homogeneous.

some cases there was an outer part composed of two or three layers. The forms were referred to the genus *Archagaricon* (p. 226), with five species, as follows: *A. bulbosum*, *A. globuliferum*, *A. radiatum*, *A. dendriticum*, and *A. conglomeratum*. The first (*A. bulbosum*) is the only species illustrated. It is probable that these bodies are really fungoid in their nature, but it seems scarcely justifiable to make so many species.

In 1877 Worthington G. Smith referred to this paper* and said that while one of the figures might pass for a species called by himself *Peronosporites antiquus*, "drawn by a bad draftsman, unacquainted with fungi," the descriptions were too indefinite to determine what the writers really had in mind.

In this same paper† Mr. Smith described a fungus under the name mentioned above. He observed it in the stem of a species of *Lepidodendron* from the Coal Measures, and described the hyphæ as septate and bearing oögonia, which contained zoöspores. Further, he stated that an enlargement of the fossil to 400 diameters showed the oögonia to be the same in size and character as similar structures belonging to the potato fungus. The average number of zoöspores in each he said was also the same, namely, seven or eight. While these observations of Mr. Smith have been criticised in many quarters,‡ it is probable that the body described is a fungus. Mr. Carruthers considers it to be such, without question. In his "Diseases of Field and Garden Crops," published in 1884, Mr. Smith referred to the criticisms that had been passed upon the fossil from time to time, and reiterated his statement that traces of zoöspores are visible in the oögonia. In Massee's recent volume,§ the subject is again discussed, and the conclusion is that the species is perhaps as well placed in the *Peronosporeæ* as in the *Saprolegnieæ*, where Williamson thought it belonged.

It should be mentioned here that DeBary has questioned the accuracy of Smith's observations in regard to the presence of oöspores and zoöspores in the living *Phytophthora infestans*. Sexual organs, however, have been observed in another species of the genus (*P. omnivora*),‖ and their presence may yet be demonstrated to the satisfaction of all in *P. infestans*. DeBary says that "septa occur in the mycelium of *P. infestans*, especially when old, but they are always isolated and very irregular." ¶ The imperfect preservation of the fossil *Peronosporites* probably accounts for the conflicting statements that have been made in regard to it. It is, too, scarcely to be expected that

* Gard. Chron., new ser., Vol. VIII, London, 1877, p. 499.

† A fossil Peronospora (*Peronosporites antiquus* W. Sm.).

‡ By Murray in the Academy, Nov. 17, 1877, who denied the existence of the zoöspores; and by Williamson in the Philosophical Transactions of the Royal Society of London Vol. CLXXII, p. 299. The latter stated that the relations of the fungus were more probably with *Saprolegniæ* than *Peronosporeæ*.

§ British Fungi: Phycomycetes and Ustilagineæ, London, 1891, pp. 213–216.

‖ Bennett & Murray, Cryptogamic Botany, 1889, p. 327.

¶ Jour Roy. Agric. Soc. England, Vol. XII, London, 1876, p. 262.

it will ever be found so excellently preserved as to settle positively its true position in classification. Bennett and Murray state that "mycele and bodies which may well be oögones are visible in the preparations" of Mr. Smith.*

A remarkable paper on fossil plants by Prof. P. Martin Duncan, has been published in the proceedings of the Royal Society of London.† The title is, "On some Thallophytes parasitic within recent Madreporaria." In the course of the paper he refers to the work of other writers on organisms in corals. The time range of the various parasites is very great, as corals from the Lower and Upper Silurian and Tertiary formations show their presence. In the latter case even the cell wall is preserved. Their vertical range in the ocean extends from the surface to a depth of 1,095 fathoms, and they can exist under temperatures ranging from 39.7° to that of the surface water. The parasitic growths are observed by means of thin transverse and longitudinal sections. Age and length of time since the canals were bored seem to have no influence on them, for they are just as perceptible in Tertiary as in recent corals. The usual appearance of the canals is that of long, dark lines, with a clear central space. The lines may branch, but are of the same size in stem and branch. Swellings are frequent and granular masses often fill spaces in the canals. Prof. Duncan proposes for the parasite the name of *Achlya penetrans*. In regard to the fossil forms he says:

From the results of my examination of Upper Silurian corals and of Lower Silurian arenaceous Foraminifera, it is evident that a parasite closely resembling *Achlya penetrans* lived within them during those remote ages. Corresponding in shape with the Silurian form of parasite are others which are fossil within the corals of later ages. The main differences between the ancient and modern forms consist in the larger caliber of some of the filaments of the first, their long, often unbranching course, and the frequent development of *Conidia*-looking bodies within them, and the spherical shape of the spores; but it is quite possible that these are not distinctions which are of specific value.

The modern coral parasite is evidently the descendant, with slight, or possibly no modification, of those which have flourished during successive world-wide changes in floras and external conditions. Hence it would, in all probability, have had its life cycle made complicated, and a metamorphosis involving vegetative and mobile stages has been superadded. It is not an assimilator of putrescent or rotten animal matter, but of the nitrogenous and undecomposed organic basis of the coral; and in this it resembles the organisms which destroy some living diptera and other aërial insecta. Moreover this resemblance in function is possibly caused by continuance of individuality; and if this be true, it adds vastly to the difficulty of placing the parasite in a philosophical scheme of classification (pp. 252–253).

The lowly organization and the simple structure of many fungi have been the possible cause of the continued existence of many of them through long periods of time. We seem scarcely prepared, however, to realize that the forms existing as parasites within corals of Silurian

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*Loc. cit., p. 530.

†Abstract in No. 171, Vol. xxv, 1876, pp. 17–18; complete in No. 174, Vol. xxv, 1876, pp. 238–257, pl. 3.

age are the same as those now living in inhabitants of the ocean. Still when we remember that the fungus simply produces threads or filaments with the occasional addition of spores; that the bathymetrical conditions have probably remained nearly the same, and that the hosts alone have changed since early geological time; and further that the fungus causing potato rot had at least its representative in plants of Carboniferous age, it does not seem so strange to find long-lived forms under other conditions. If, however, the parasitic *Achlya penetrans* of modern seas is identical with the parasite of Silurian seas, the case is without a parallel in the organic world.

In 1877 Prof. L. Lesquereux published a paper entitled "A species of fungus recently discovered in the shales of the Darlington coal bed (Lower Productive Coal Measures Allegheny River series) at Cannelton, in Beaver County, Pa."* The name *Rhizomorpha sigillariæ* is given to the specimen, which was found beneath the bark of a species of *Sigillaria*. A figure of it was sent to Dr. Casimer Roumeguere, of Toulouse, France, who concluded that it bore a great resemblance to living examples of *Rhizomorpha*. The figure given by Lesquereux is reproduced below. (Fig. 1.)

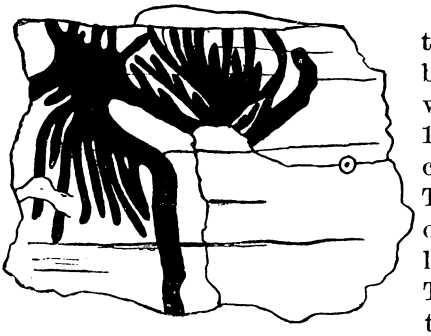

FIG. 1.—*Rhizomorpha sigillariæ*. Lesqx.

The striking resemblance which this figure had to certain insect burrows under the bark of trees was pointed out by the writer in 1885† and a further examination confirms this belief in its origin. The genus *Rhizomorpha* is now recognized as simply the sterile mycelium of various species of fungi. This fact does not of course militate against the fossil being a fungus, but if comparison be made between it and the burrows of various living insects, the resemblance is most marked. Some of these are shown in the figures given on the following page (figs. 2 and 3).

The burrows, although more or less constant in form for each individual species, present great variations. With a sufficiently large series of examples it might be possible to find some presenting a greater resemblance to the fossil, but the general aspect of the modern insect mines is sufficient to induce the belief that the supposed fossil is not a fungus but an insect burrow. This fact is rendered the more probable when it is remembered that remains of insects are found in the same beds as those containing the fossil *Rhizomorpha*.

*Proc. Am. Phil. Soc., Phila., Vol. XVII, 1887, pp. 173–175.

†Remarks on a supposed fossil fungus from the Coal Measures. Jour. Cin. Soc. Nat. Hist., Vol. VIII, 1885, pp. 157–159.

Another fossil described as a fungus was later on shown not to be such. It was originally named by Goeppert *Gyromyces ammonius*. It

FIG. 2.—Larval burrow of *Bostrychus typographus*. Nat. size. (After Hess.)

was found in Saxony under the bark of certain coal plants and subsequently in rocks of Carboniferous age in North America. It has been shown by Dawson to be really the spiral tube of an annelid, and was

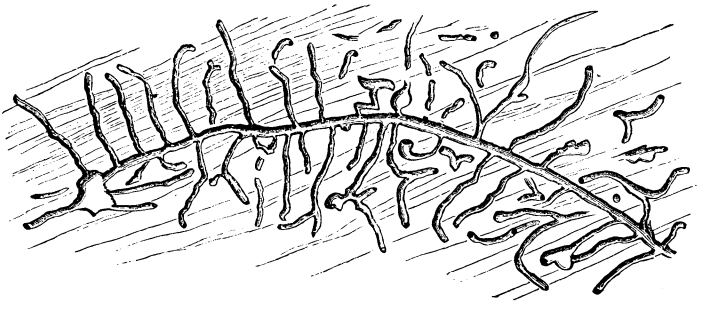

FIG. 3.—Burrow of *Carphoborus bifurcus*. Nat. size. (After Packard.)

named by him *Spirorbis carbonarius*. Lesquereux also considered the fossil to belong to the animal kingdom and figured it as such in volume 2 of the Geological Survey of Illinois, 1866 (p. 462, pl. 38, fig. 6).